QUICK LAB

Escape from a Planetoid

TARGET SKILLS

- Analyzing and interpreting
- Communicating results

Imagine that you are stationed on a spherical planetoid (a small planet-like object) somewhere in space. The planetoid has a mass of 1.0×10^{22} kg and a radius of 1.0×10^{6} m. You want to send a small 6.0 kg canister off into space so that it will escape the gravity of the planetoid and not fall back to the surface. You can accomplish this task by estimating the amount of work that must be done to lift the canister to 10 times the radius of the planet. You cannot use the formula $W = F\Delta d \cos \theta$, because the force changes with the distance from the centre of the planet. Therefore, you will need to use a graphical method, such as the one described in the following steps.

- Prepare a table with two headings: Distance from the centre of the planetoid (d), and Gravitational force (N). In the first column, write the following distances: 1.0×10^{6} m, 2.0×10^{6} m, 3.0×10^{6} m, and so on, up to 10.0×10^{6} m. (Notice that these values are multiples of the radius of the planetoid, where 1.0×10^{6} m represents the surface of the planetoid.)
- Calculate the force of gravity on the 6.0 kg canister for each of these distances.
- Plot the graph of gravitational force (y-axis) against distance from the centre of the planetoid. Since your graph is of force versus position, the area under the graph represents the amount of work required to move the canister to a separation of 10 radii (9 radii from the surface). Graphically determine the area under the curve and, thus, the amount of work done.

  Note: There are several ways to find the area under the graph. One is to determine the graphical area represented by each square and then count the number of squares under the curve. Where the curve actually crosses a square, include the square if half or more of it is under the curve. Another method is to divide the area up into different regions and approximate their areas by using figures such as trapezoids and triangles.

Analyze and Conclude

1. If the canister has been lifted a distance of 10 radii and remains there, what type of energy does the area under the curve represent?
2. To launch the canister so that it will be able to travel straight out to a separation of 10 radii, how much kinetic energy must it be given at the start? From this kinetic energy, determine the required speed that would allow the canister to reach this separation.
3. The gravitational force that is trying to pull the canister back is extremely small at a separation of 10 radii. With only slightly more speed, the canister would never return to the planetoid, so the speed that you found is essentially the escape speed for the planetoid. What is the escape speed for this planetoid?

Apply and Extend

4. Considering the energies involved, does the canister have to be thrown straight up at its escape speed for it to be able to escape? Give reasons for your answer.